National Ice Center
Naval Ice Center
4251 Suitland Rd.
FB #4, Room 2301
Washington, DC 20395

Distribution Statement

National Ice Center/Naval Ice Center
Seasonal Outlook
Western Ross Sea and McMurdo Sound
2005-2006

Sean R. Helfrich and Craig Evanego

Approved By: LT. Kelly Taylor

Readers: Paul Seymour
LTJG Natalie Scharnus
Dr. Pablo Clemete-Colón

National Ice Center/Naval Ice Center
Seasonal Outlook
Western Ross Sea and McMurdo Sound
2005-2006

Authors: Sean R. Helfrich
Craig Evanego

Approved by: Kelly Taylor
LT, USN
Operations Officer

Readers:
Paul Seymour; Operations Technical Advisor
LTJG Natalie Scharnus, Ice Products Branch Chief
Dr. Pablo Clemente-Colón, NIC Chief Scientist

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

This outlook presents the expected positions of the sea ice "edges" in the Western Ross Sea and the depiction of the mid-October fast ice boundary in McMurdo Sound. Figure 1 is a map of the areas of interest within McMurdo Sound. Ice edge positions at 15-day intervals beginning 15 December are forecast from a 15 October baseline analysis to the end of the shipping season in mid-February. The term "edges" is used to indicate and describe the typical "hourglass" melt pattern of the Ross Sea ice cover. This pattern of pinching off the pack ice occurs due to the concurrent ice melt along the northern ice edge and an enlarging polynya adjacent to the Ross Ice Shelf. The distance, concentration, and thickness of ice expected to remain between these two edges is an important factor in this outlook as a measure of predicted severity along the shipping route located between 175E-177W. Additional factors evaluated for the forecast are sea ice model estimates, atmospheric forecast model estimates, climate teleconnective patterns, the ice thickness and linear distance from Hut Point to the fast ice edge in McMurdo Sound, and a new linear four parameter statistical technique. The linear distance is measured along a bearing of 330 degrees from Hut Point to the closest access point at the fast ice edge for incoming vessels. Further fast ice edge estimates used optima distances of the ice edge from Hut Point

.

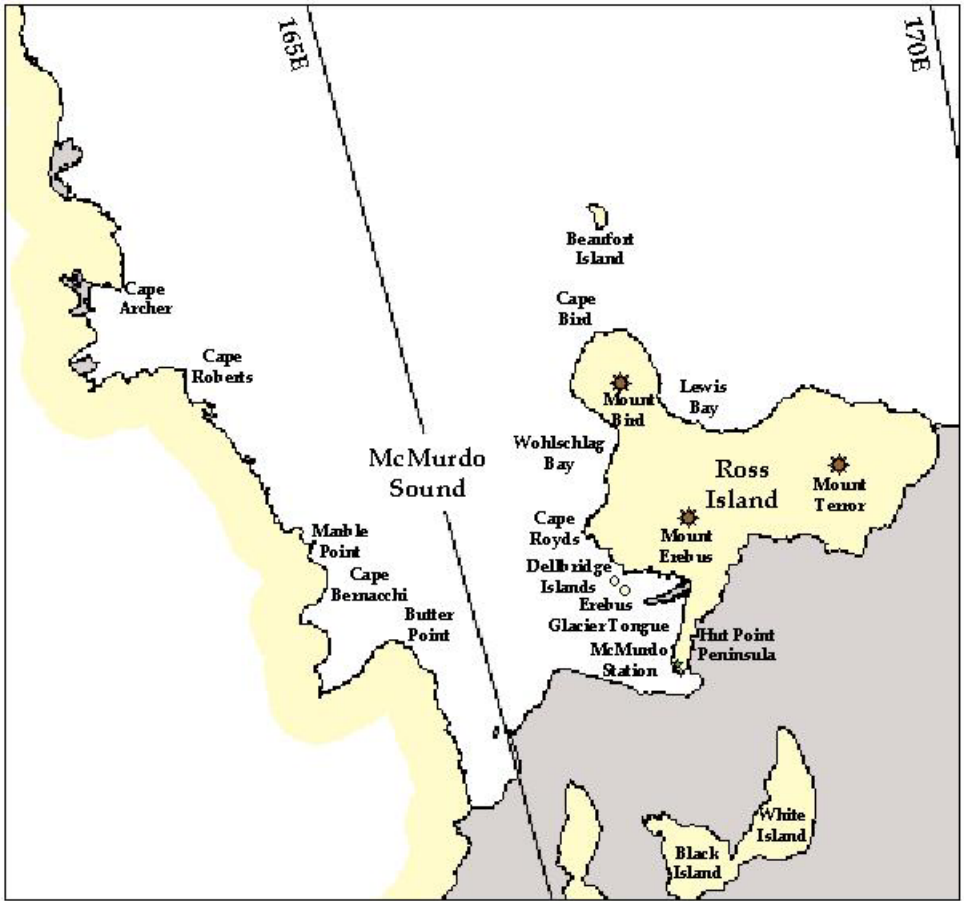

Figure 1 Map of McMurdo Sound

The categories of environmental data used to compile this outlook include:

1) Remotely sensed imagery: RADARSAT from the Canadian Space Agency, infrared satellite imagery from the Defense Meteorological Satellite Program (DMSP) Operational Line-Scan System (OLS), NOAA Advanced Very High Resolution Radiometer (AVHRR), NASA Moderate Resolution Imaging Spectroradiometer (MODIS), DMSP Special Sensor Microwave Imager (SSMI), QUIKSCAT, EnviSat ASAR Wide Swath Mode, EnviSat Global Monitoring Mode, and Advanced Microwave Scanning Radiometer for EOS (AMSR-E),

2) drilled ice thickness measurements in McMurdo Sound,

3) meteorological data received from McMurdo Station for March through September 2005,

4) National Centers for Environmental Prediction (NCEP) / National Center for Environmental Research (NCAR) Reanalysis Data through September 2005, and

5) National/Naval Ice Center sea ice climatology for the Ross Sea.

The rates of recession for the Ross Sea ice edge and the McMurdo Sound fast ice edge are derived using an analogue forecasting technique that relates historical observations of pre-season ice extent and thickness to the predicted severity of austral summer ice conditions. This relationship is based upon the premise that ice conditions of similar areal extent and thickness will follow the same historical progression of decay. This "persistence" of antecedent ice conditions and recession rates has been well documented during the many years of Operation DEEP FREEZE.

Operation DEEP FREEZE is the unclassified code name given the operations previously conducted by the U.S. Navy to provide operational and logistic support to the United States Antarctic Program (USAP).

The estimated position of the ice edge and the "opening date" are based on the collimation of evidence from analogue years adjusted to reflect alterations of current conditions from past conditions, forecast atmospheric models, oceanic models, and cryospheric models. In addition, a new empirical model based on the Amundsen Sea Low (ASL) sea level pressure, meridional winds off the Ross Ice Shelf, the surface momentum flux over the Ross Sea, and the surface air temperatures over the western Ross Sea. This new technique will allow for future inclusion of additional variables (if available). An optimal model has yet to be identified and the technique is still subject to peer review.

II. Initial Ice Conditions

The National Ice Center (NIC) ice analysis from 10-14 October 2005 (Figures 2a-2c) reveals that the position of the northern ice edge is at a climatological maximum from 150E to 175W and near a climatological mean from 175W to 150W. Considerable amounts of old ice extend south of the Drygalski Ice Tongue to the north of McMurdo Sound. Much of this old ice has survived 3-4 years of melt, with fast ice 5-8 years old surrounding the coastline. Isolated concentrations of thicker old ice are believed to exist in areas south and west of the Balleny Islands (western Ross Sea) and south and east of 69S/175E. Historically, a flaw lead occurs along the Ross Ice Shelf during the first week of November. This flaw lead is starting to occur east and north of Ross Island but still has a few more weeks before it becomes a persistent feature. (Figures 3 & 4). As of 13 October 2005, iceberg C-16 remains grounded near 77°05'S/167°46'E, B-15A is centered near 72°41'S/172°19'E, B-15J is centered near 77°13'S/169°07'E, and B-15K centered near 75°11'S/171°33E. Figure 3 shows the relative positions of these icebergs. Total concentration and stage of development of sea ice and icebergs is labeled using World Meteorological Organization (WMO) international system of sea ice symbols (Figure 5). Fast ice edge measurements reveal a residual edge from 2003-04 season of 13.5 NM from Hut Point, and minimal navigation distances of 60 NM from Hut Point to the Fast ice edge south of B-15K.

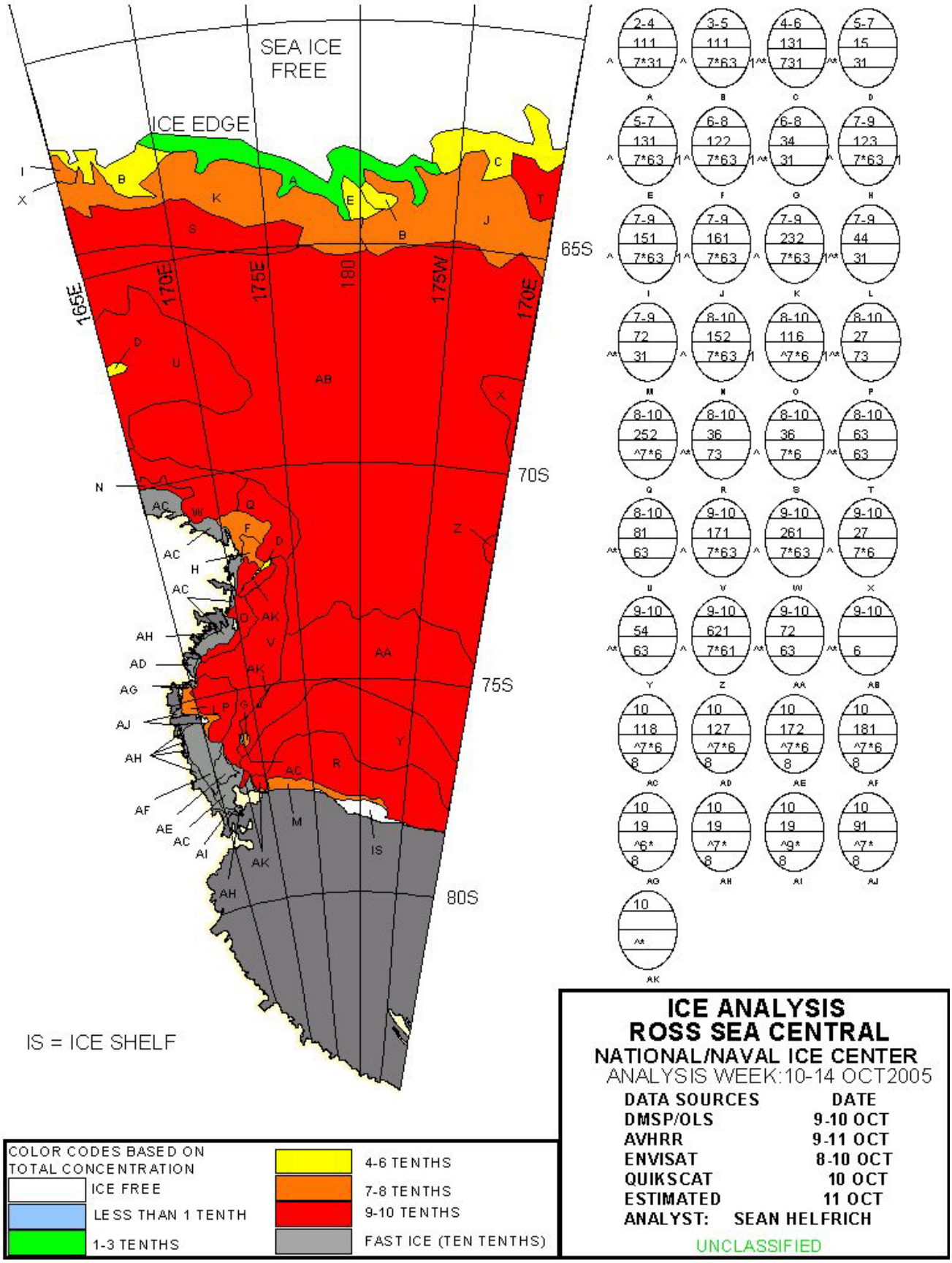

Figure 2a 10-14 October 2005 Ross Sea Central Ice Conditions

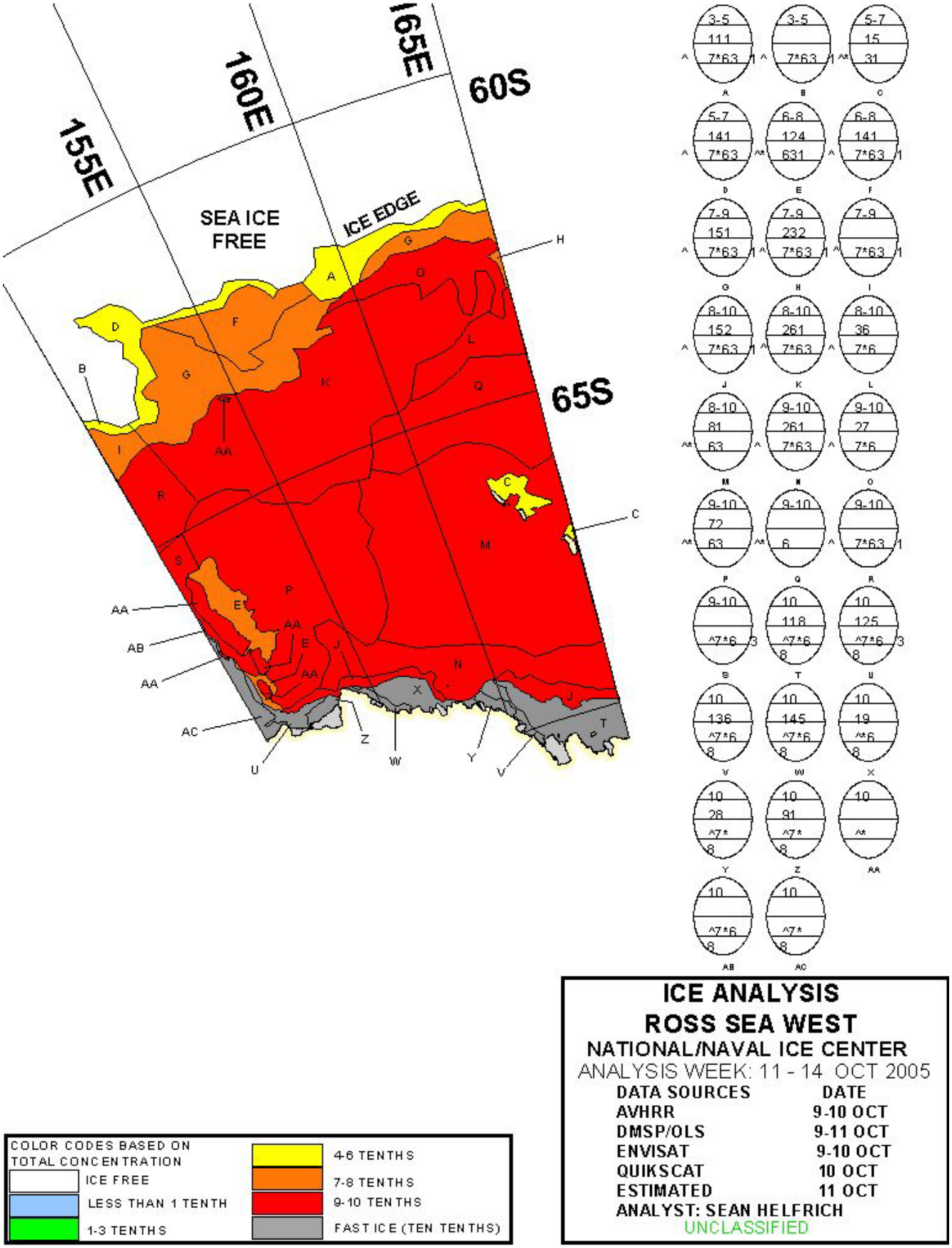

Figure 2b 10-14 October 2005 Ross Sea West Ice Conditions

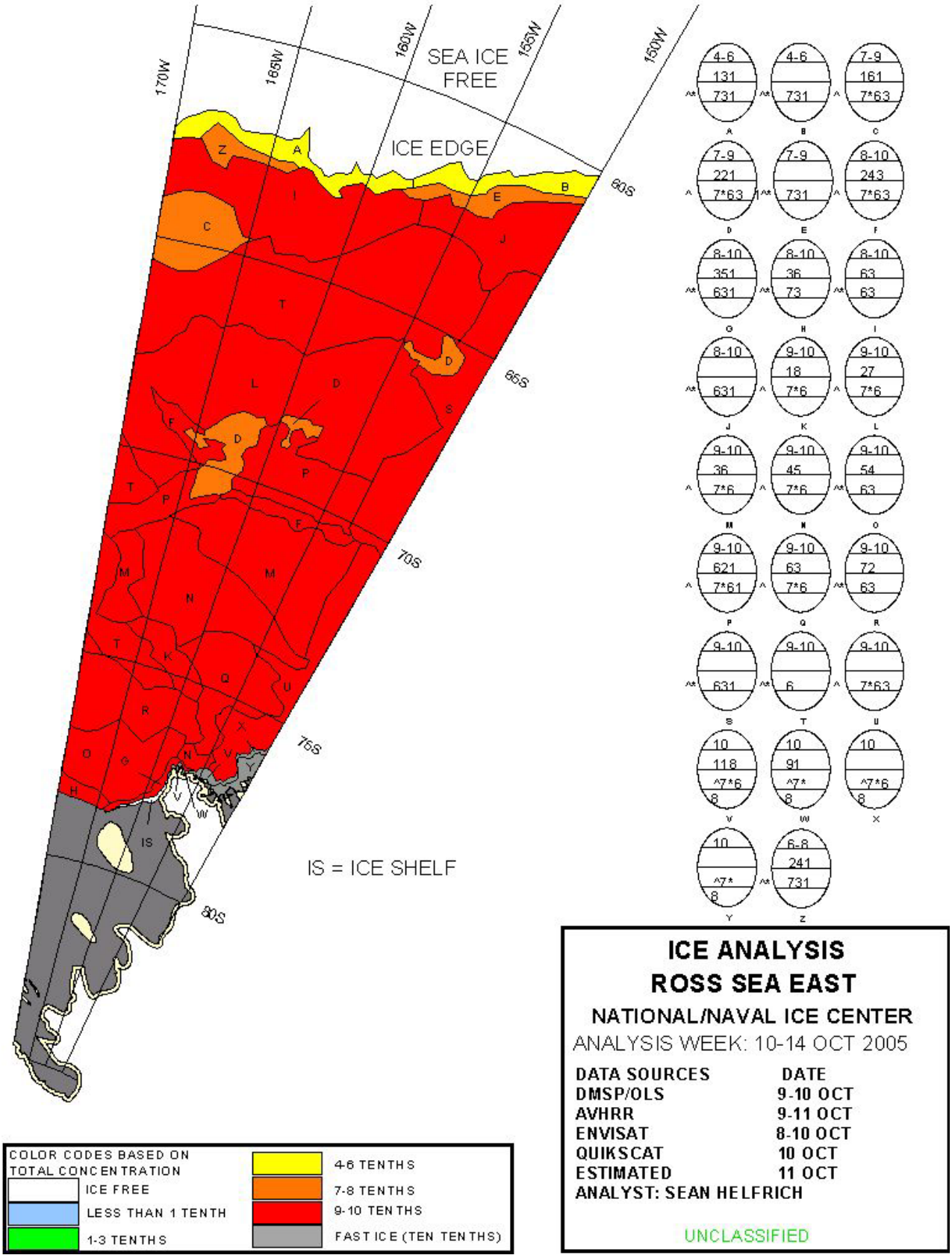

Figure 2c 10-14 October 2005 Ross Sea East Ice Conditions

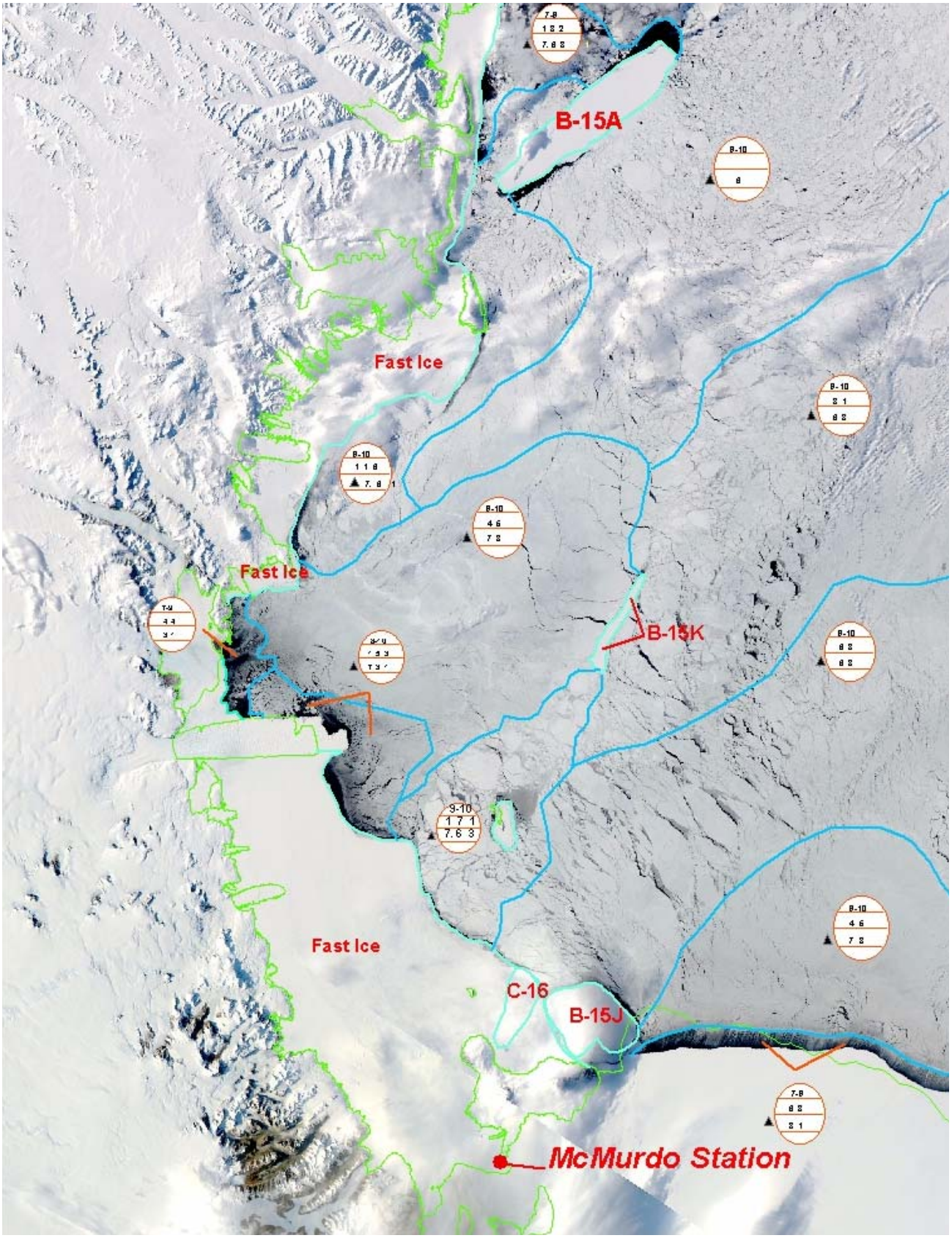

Figure 3 12 Oct 2005 - MODIS - aqua (bands 143)

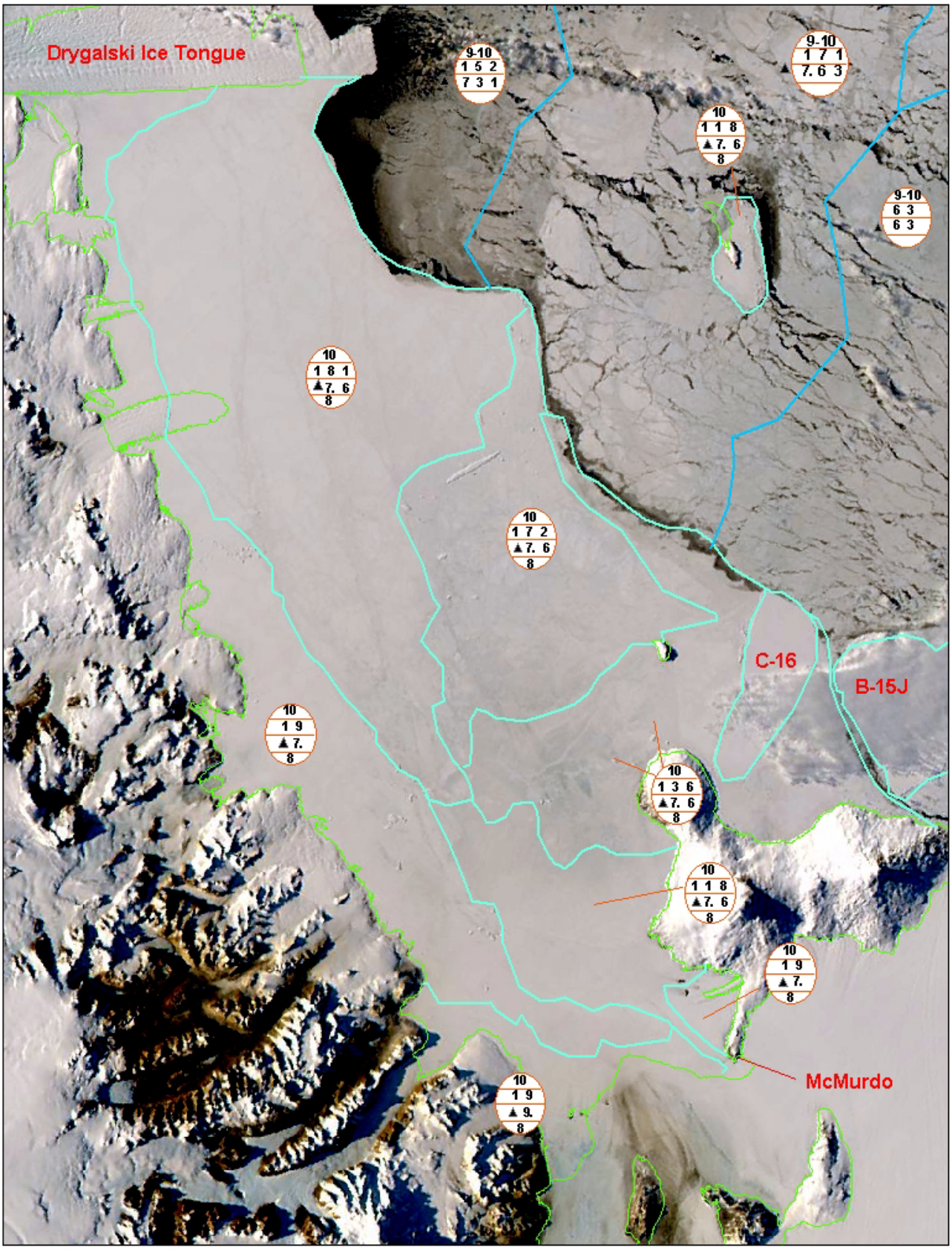

Figure 4 10 Oct 2005 - MODIS - aqua (bands 143)

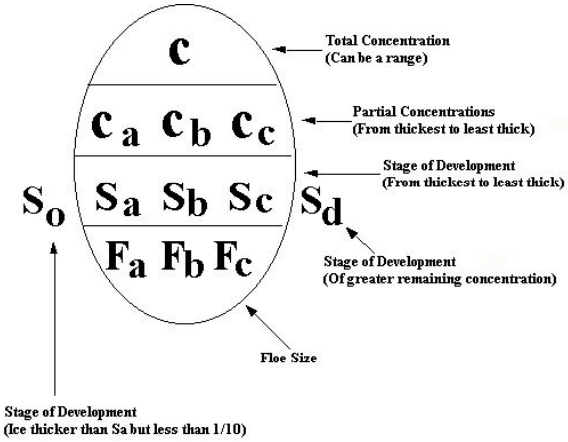

Figure 5 WMO Egg Code Example

STAGE(S) OF DEVELPOMENT

1 = New ice (0-10cm)

3 = Young ice (10_30cm)

6 = First year (30_200cm)

7 = First year thin (30_70cm)

1.= First year medium (70-120cm)

4.= First year thick (120-200cm)

7.= Old ice (survived at least one summers melt)

III. OUTLOOK

Ross Sea

The average opening date for the icebreaker-led convoys to transit the western Ross Sea shipping lane is historically 7-10 January. Typical conditions for the opening include a 20-50 N wide "band" of lesser (<4/10 tenths) concentration ice. **A later than normal opening date is forecast this year. This delay is likely to be in range of 1.5-2 weeks.** This forecast is based on:

a) *Substantially Lower Surface Air Temperatures*. Surface air temperatures over the Ross Sea have been substantially below normal. NCEP reanalysis model averages indicate this has been the coldest winter (Jun-Sep) over the 57-year record. Air temperatures in McMurdo suggest an abnormally cold winter, as well. This would increase both the ice thickness and the subsequent time required over the coming months to melt the first/multi-year sea ice. While the greater ice thickness conditions will require more time to melt, global climate models (GCMs), like the Scripps' Global Spectral Model and the National Centers for Environmental Prediction model, indicate slightly warmer than normal conditions in the summer over the Ross Sea. This will aid the melt of sea ice along the Ross Ice Shelf, although it will take substantial warming to recess the thicker ice located along the ice edge.

b) *Amundsen Sea Low Anomalies.* The Amundsen Sea Low (ASL) seemed to be displaced west of its normal location, but with reduced magnitude during the austral summer of 2005. The western displacement should increase offshore winds over the Ross Ice Shelf, however the reduced magnitude generated only a slight increase in meridional wind from the shelf. The increase in wind should decrease ice thickness along the shelf. While this will play a factor in the regression of ice from the Ross Ice Shelf it will not serve to melt the thicker than normal ice between 65S-70S. Furthermore, GCM forecasts suggest that the ASL displacement and magnitude shift is unlikely to continue through austral summer.

c) *Near Normal Sea Surface Temperatures along Ice Edge*. Near normal sea surface temperatures have been measured along the western Ross Sea ice edge from Mar-Sep 2005. These are thought to be associated with normal SST conditions in the tropical Pacific Ocean. The current outlook from NOAA's Climate Prediction Center suggests near normal conditions will persist until early 2006. Anomalies in the SSTs in the central Pacific Ocean have been shown to affect ice edge conditions, particularly when ASL is near climatologically normal (Rind et al., 2001; Kwok and Comiso, 2002; Browmwich and Rogers, 2001). While the ASL is not at 'normal' conditions this season, there is likely to be little affect from SSTs to promote accelerated ice edge recession, due to the near normal SST conditions.

d) *Extensive Fast Ice Extent in McMurdo Sound.* The current fast ice extent in McMurdo Sound has only been matched during the 2004/5 seasons. The majority of this ice has survived through 2 years, but is likely to fracture and flush from the sound. Isolated areas of fast ice with large multiyear content located along the shoreline from Drygalski Ice Tongue south to Cape Royds are likely to remain later into the summer melt.

e) *Icebergs*. Icebergs scattered in the western Ross Sea continue to shift along with oceanographic currents typical throughout the region. Recent seasons with heavy iceberg presence in the Ross Sea have been associated with delayed opening dates. Due to the transit of B-15A and B-15K north along the Scott Coast, typical of oceanographic currents, there is likely to be heavy concentrations of ice on the windward side of the icebergs. Since icebergs typically move at a slower velocity than sea ice, the sea ice will be restricted from advecting by the substantial sized icebergs. This will result in greater ice concentrations along their windward side.

f) *Statistical Model Results*. The newly developed multiple linear regression method for determining ice recession predicted Jan 28th as a navigable date. Since this tool is still under evaluation and has not undergone peer review, it is treated as only one tool within the overall assessment. This linear empirical model was used in forecasting previous opening dates, and since 1972 has resulted in only two years exceeding 15 days from the actual opening date. With this low variability, it appears able to give an objective estimate of previous opening dates with reasonable accuracy. The date provided by the model has been adjusted based on the additional variables used in the forecast.

Comparing the current year to previous years with similar pre-season areal ice extents (2002, 2003, and 2004), **it is projected that the Ross Sea ice "band" will be 100-120 NM in width and vessels will require icebreaker escort until about 23 January 2006 (Figure 6).** Navigable ice conditions for unescorted vessels (<4/10 tenths) are expected after 23 January 2006.

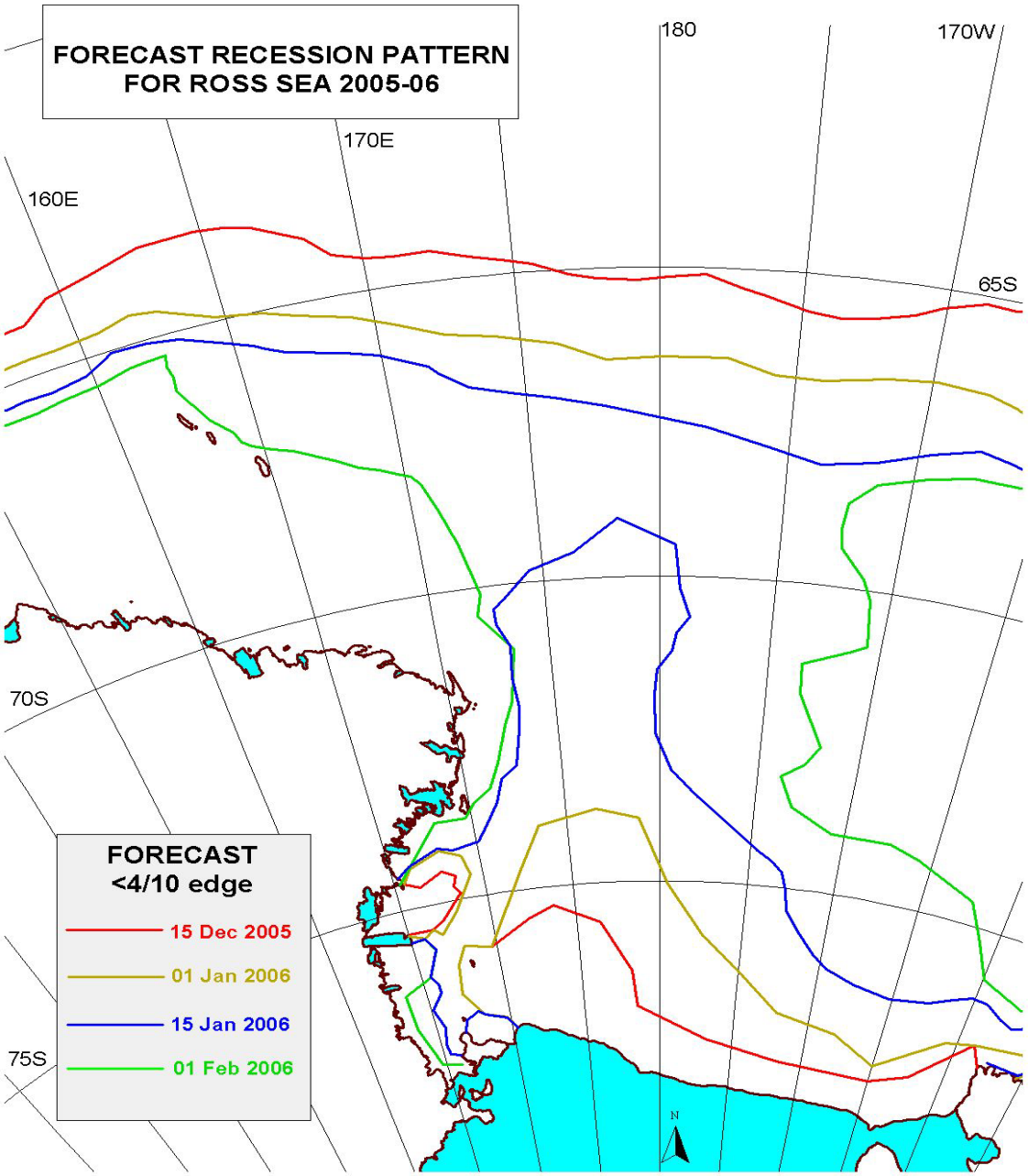

Figure 6 Forecast Recession Pattern for Ross Sea (2005-2006) Season)

McMurdo Sound

The entire 2005 winter season (March-September) had colder than normal temperatures. This allowed for significant thickening of the fast ice in McMurdo Sound. Current observed fast ice thickness around McMurdo is 217 cm in first-year medium, first-year thick and multi-year ice within the previous years' ice channels. The historical average breakout date of the land fast ice at Hut Point is 15 February. Much of the first-year-only fast ice in McMurdo Sound is likely to fracture and flush from the sound. Fast ice with large multiyear content, located along the shoreline from Drygalski Ice Tongue south to Cape Royds is likely to remain throughout the summer melt. This is believed likely due to the below average air temperatures, delayed breakup of thicker ice, expanded fast ice boundary, and the ongoing presence of icebergs B-15J and C-16. If the prediction of the first and second year ice from McMurdo Sound advecting north hold true, the ice cut during the icebreaker transit should flush from the channel. This would provide a lane of safer navigation along the channel with reduced ice concentrations and thickness. Existing conditions are demonstrated in Figure 4 (MODIS) and Figure 7 (ASAR).

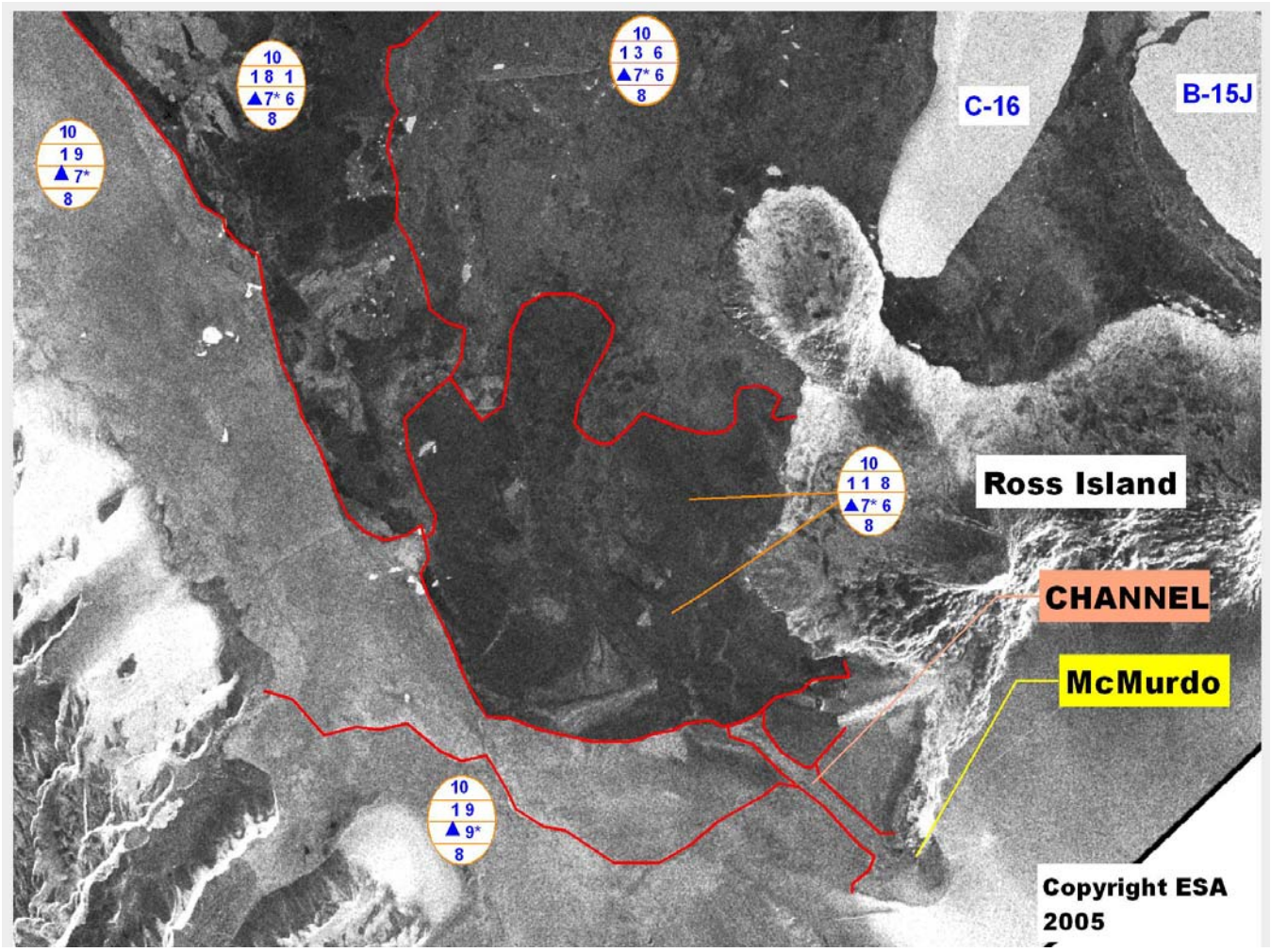

Figure 7 17 July 2004 Annotated EnviSat Wide Swath Image - McMurdo Sound

Icebergs and Shelf Ice

Due to the significant calving of the Ross ice shelf over the past few years, icebergs have posed a greater than normal hazard to navigation in the Ross Sea, and have had a significant influence on the ocean currents, weather, and sea ice conditions in McMurdo Sound. While the number and magnitude of icebergs in McMurdo Sound is less than last season, the presence of 4 icebergs in the western Ross Sea is still likely to impact ice cover. Two considerably large icebergs are currently located in the vicinity of McMurdo Sound: C-16 and B-15J. Grounded iceberg C-16 prevents the prevailing winds and the Antarctic Coastal Current from "flushing" the sea ice northward out of McMurdo. Last year, C-16 moved slightly from the location where it had been grounded since 2002. While C-16 is currently grounded, it could become afloat again in 2006. The possibility of B-15J floating erratically and colliding with C-16 would only aid in the displacement of C-16 from its current location. B-15J remains just east of C-16, where it appears to be caught in an eddy. B-15J will likely remain in its current location until the eddy ceases or C-16 is dislodged. Iceberg B-15A, is currently headed north along the Scott Coast, out of McMurdo Sound. While this will likely aid the flushing of ice from McMurdo Sound, it may trap heavy concentrations of sea ice on its windward side, while generating an open water area on its lee side. This should allow greater ice concentrations than normal around Cape Adare by Dec 2005-Jan 2006. The long and slender iceberg B-15K is also headed north along the Scott Coast. This iceberg will also act to impede sea ice regression from the western Ross Sea. The presence of both icebergs is likely to generate an eastward displacement in the regression pattern and further delay the opening of the Ross Sea to unescorted vessels.

IV. REFERENCES

Bromwich, D. H. and A.N. Rogers: 2001*: The El Nino-Southern Oscillation modulation of west Antarctic precipitation, in The West Antarctic Ice Sheet: Behavior and Environment, Ant. Res. Ser*., **77**, Ed. R. B. Alley and R.A. Bindschadler, 91-103, AGU, Washington D.C.

Chen, D., and X. Yuan, 2004: A Markov model for seasonal forecast of Antarctic sea ice. *J. Clim.*, **17**, 3156-3168.

Kwok, R., and J.C. Comiso, 2002: Southern Ocean Climate and Sea Ice Anomalies Associated with the Southern Oscillation. *J. Clim.*, **15**, 487-501.

Rind, D., M. Chandler, J. Lerner, D.G. Martinson, and X. Yuan, 2001: Climate response to basin-specific changes in latitudinal temperature gradients and implications for sea ice variability. *J. Geophys. Res.* **106**, 20161-20173.